ಬೃಹತ್ ಬೆಂಗಳೂರು ಮಹಾನಗರ ಪಾಲಿಕೆ
Bruhat Bengaluru Mahanagara Palike

DETAILED PROJECT REPORT

CONSULTING SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT FOR

Name of Work: Improvements, Restoration to roads and drains at Dasarahalli, Saraipalya and Rachenahalli Surrounding Areas in ward no. 06

COST OF THE PROJECT: 1500.00 LAKHS

Submitted To:
The Executive Engineer,
Yelahanka Project Division,
B.B.M.P, Bangalore.

SILICON
CONSULTING ENGINEERS
S-1317, 4TH CROSS
BEL II STAGE, BHARATHNAGAR,BANGALORE-91.
CELL : 9448353883

CONTENTS

Chapter No.	Description	Page No.
1	Introduction	3-8
2	Investigation & Surveys	9-12
3	Design Standard & Specification	13-17
4	Design & Proposals	18-25
5	Project Cost Estimates	26

Annexure

Annexure A. 1.1 Key Map

Annexure A.4.1 Flexible Pavement Design

Rigid Pavement Design

Annexure A.5.1 Detailed Cost Estimate, Rate Analysis, Draft Tender Schedule

Chapter -1

INTRODUCTION

1.1.1 General

Bengaluru is the capital of India's southern Karnataka state. The center of India's high-tech industry, the city is also known for its parks. It is also known as the Garden City because of its many beautiful gardens and parks. By Cubbon Park, Vidhana Soudha is a Neo-Dravidian legislative building. Former royal residences include 19th-century Bangalore Palace, modeled after England's Windsor Castle, and Tipu Sultan's Summer Palace, an 18th-century teak structure.During the last couple of decades, city has witnessed drastic increase in population, change in land use pattern of the city, life style of the people and their commuting habits and the revolutionary changes that has taken place in the automobile industry. This has contributed to the growth of vehicular traffic in an enormous way.

1.1.2 City Background

It also called the Silicon Valley of India , because of the high concentration of IT industry. Bangalore is rated to one of the fastest growing cities in Asia with a current population of more than 10 million. During the last couple of decades, city has witnessed drastic increase in population, change in land use pattern of the city, life style of the people and their commuting habits and the revolutionary changes that has taken place in the automobile industry.

1.1.3 Population

The Bangalore city population is currently more than 11 million and increasing in a forward march. The lifestyle of the citizens is changing day to day due to globalization and introducing of new brands in all sector. Bangalore, the fastest growing city of India, comprises of a dynamic blend of people, belonging to various religions, castes and communities. With the introduction of information technology in the city, it has assumed an international character. IT professionals not only from the various parts of India, but also that of the world, are migrating to the city. This has led to Bangalore becoming more like the melting pot of various cultures. Read on to know more about the people and lifestyle of Bengalooru, India.

1.1.4 Traffic growth

What adds to the traffic pressure in Bengaluru in particular is that there is very little scope for expansion of roads and the need to use existing roads for smooth movement of vehicles is

even more pronounced. It thus becomes mandatory for the administration to ensure better parking facilities. So far, the government and the BBMP have not taken this issue seriously and now the situation is such that it needs to be addressed seriously and effectively. Rapid population growth because of IT and other associated industries in Bengaluru led to an increase in the vehicular population to about 1.5 million, with an annual growth rate of 7-10%. With the increase in population and the expansion of the city, the problem of connectivity of the populace has arisen. Quite obviously personalized modes of transport have grown at a tremendous rate and two wheelers along with the cars almost comprise 90% of the total registered vehicular population in the city. Two wheelers constitute more than 70% of the total volume, while cars comprise 15%, autos 4% and the remaining 8% includes other vehicles such as buses, vans and tempos.

Project Location

The Project includes **Improvements, Restoration to roads and drains at Dasarahalli, Saraipalya and Rachenahalli Surrounding Areas in ward no. 06**. The Project area is in Byatarayanapura Assembly constituency, Bangalore. The Project stretch includes main roads and cross roads of Ward 06 Thanisandra. By considering these reasons the roads are taken up for Development with Asphalting depending upon the site scenario.

Key Map of the roads proposed is enclosed in **Annexure A.1.1.**

M/s. SILICON CONSULTING ENGINEERS is entrusted by BBMP to carry out the work of Preparation of Detailed Estimate and Report for the above said work.

Accordingly we **M/s. SILICON CONSULTING ENGINEERS** have commenced the consultancy works as per the scope of services described in the RFP document.

1.2 Scope of Work

The Scope of Services of the Consultancy includes the following:

Inventory and condition surveys for alignment.

- Engineering surveys and investigations
- Improvement to the existing pavement and drains, such as horizontal and vertical alignment, curve straightening, rising of the road level in low lying areas above the HFLs, concentric widening / eccentric widening etc.
- Design of Pavement.
- Design of lateral side drains and Cross drainage works such as culverts etc
- Rate analysis of scheduled items, BOQ and Cost estimates.

- ❖ Final Detailed Project Report and final drawings
- ❖ Photos of the project roads

1.2.1 Engineering surveys and investigations

The engineering surveys and investigations shall be divided into the following components:

- Topographic, alignment and land use survey
- Inventory survey
- Bridge condition survey
- Soil, geo-technical, material, hydrology and drainage surveys

1.2.1.1 Topographic, alignment and land use survey

The activities and Deliverables forming part of the topographic, alignment and land use survey are described below:

(a) Divide the Project Highway into various stretches as per terrain classification.

(b) Identify sections of Project Highway which require raising. Such sections will be identified with attention being paid to the previous history of submergence and the extent to which the sub grade is likely to be affected by the capillary action if the section is not raised.

(c) As far as possible, the existing alignment would be retained subject to the following requirements:

(d) Identify stretches where the gradients are steeper than the ruling gradient for the relevant terrain condition. Work out and prepare an improvement plan for the vertical alignment in such stretches.

(e) Identify stretches involving construction of new bridges and other structures including those requiring reconstruction and their approaches. Work out proposal for location of such structures and alignment of approaches.

(f) Based on the improvement plans of horizontal and vertical alignment worked out as a result of tasks in prepare alignment plans, cross-sections of the entire Project Highway.

(g) A set of cross-sections of the existing road at equal intervals for each section shall be provided by the Consultant. These cross-sections along with proposed improvement plan and preliminary design shall form the basis of preparation of indicative BOQ for the Project Highway.

1.2.1.2 Road inventory survey

(a) An inventory of road, culverts, bridges and other structures like railway over/under bridges, flyovers (grade separated structures), underpasses and overpasses.

(b) Identification of stretches of the Project Highway which -

(i) are affected by frequent flooding;

(ii) are subjected to water logging;

(iii) pass through black cotton soil area;

(iv) pass through marshy area; or

(v) pass through weak soil stratum

(c) Identification of sections in cutting.

(d) Identification of culverts requiring:

(i) Reconstruction (all culverts which are structurally distressed shall be reconstructed as new structures).

(ii) Widening (all existing culverts which are not to be reconstructed shall be widened equal to the roadway width).

(iii) Repairs and/or rehabilitation along with preliminary proposals.

(iv) New construction

1.2.1.3 Road condition survey

The Consultant shall undertake a survey of the visual condition of the pavement and shoulders of the Project Highway. The Consultant should also report if distresses are observed in the pavement and shoulders. It will also identify sections requiring reconstruction.

1.2.1.4 Structure condition survey

(a) The Consultant shall carry out a detailed inspection of every structure

(b) For each structure, the Consultant shall indicate the distresses observed, if any, in respect of various components of the structures. On the basis of the distresses observed, the Consultant shall divide the structures into the following categories:

(i) structures requiring reconstruction immediately as part of first stage development (all such structures shall be provided as new structures);

(ii) structures where distresses are not so severe and reconstruction can be postponed to a subsequent stage say for a period of 7 to 8 years; if any major repairs are required in the meantime, these shall be so indicated for each such location;

(iii) Structures requiring repairs and/or rehabilitation (for such structures indicate preliminary proposals for repairs and/or rehabilitation);

(iv) Structures requiring widening (for such structures indicate widening methodology); and

(v) Structures that shall be retained.

1.2.1.5 Soil, geotechnical, hydrology and drainage surveys

(a) The characteristics of the existing soil of the Project Highway.

(b) The determination of sub grade CBR (soaked) of the Project.

(c) Benkleman Beam Deflection measurements on the Project Highway.

(d) Preliminary hydraulic data for structures, design discharge, HFL, LWL, etc. with a view to checking adequacy of existing waterway.

(f) A broad assessment of the drainage condition and requirement of the Project Highway.

1.2.1.6 Road signs, safety devices

(a) The Consultant shall propose provision of Road Signs, Pavement Markings, Safety Barriers, Railings, Delineators.

(b) The Consultant shall propose overhead signs on the Project Highway and provide an outline of the same giving size and location.

1.3 Project cost

The Consultant shall work out indicative BOQ of various components and prepare cost estimates of the Project Highway with a break up of cost for each component separately.

1.4 Organisation of Detailed Project Report

The Methodology, as detailed in the Project proposal, it has been followed for carrying out the necessary Investigations and for the Preparation of Detailed Estimate and Report.

This Report includes the following.

- Chapter 2: Investigation & Surveys
- Chapter 3: Design Standard & Specification
- Chapter 4: Design & Proposals
- Chapter 5: Project Cost Estimates

Chapter -2
ENGINEERING SURVEYS AND INVESTIGATIONS

2.1 General

Various surveys and investigations that are the essential inputs for detailed engineering design are detailed in this chapter. All the relevant maps / data / details available with the concerned departments have been collected, compiled and reviewed. Particular attention has been given to past / historical data / reports. A review of the past data available in the various studies has been listed out and such available data has been made use of, after updating / augmenting the data wherever necessary. The data as collected has been made use of in analysis, design, formulation of improvement proposals and costing. The activities have been performed on several fronts fully complying with the requirements. The activities that are carried out are brought out hereunder.

The various engineering surveys / investigations of the road sections include:

- Reconnaissance Survey.
- Visual Topographical Survey.
- Road Inventory Survey.
- Pavement Condition Survey.
- Visual Condition Survey.
- Bridge condition survey
- Soil, geo-technical, material, hydrology and drainage surveys

2.2 Reconnaissance Survey

Reconnaissance Survey of the road, considered for improvements, has been carried out to identify the general condition of roads, drains, culverts and bridges for further surveys / investigations, to understand kind of establishments along the stretches of roads and to work out land acquisition scheme. Making use of the observations / data collected during reconnaissance survey, detailed schedule for surveys / investigations required for the project has been finalized.

2.3 Visual Topographical Survey

Topographic Survey has been conducted all along the corridor by physically measuring the Road Width, Footpath Width, Drain Width, Alignment of Road and with the aid of Google Maps.

2.4 Road Inventory Survey

A detailed inventory and condition survey of road sections has been carried out by making use of well structured inventory data format. It was compiled in tabular form, developed using Excel computer software. Various data collected during the road inventory broadly include.

- Type of terrain.
- Land use.
- Carriageway width.
- Type of surfacing.
- Shoulder, Median, Drain (tertiary / shoulder), Footpath - type and width.
- Road Geometry.
- Road Furniture.
- Illumination.
- Salient Buildings & Structures.
- Road Intersection(s) and their details.
- Land width (RoW).
- Culverts, bridges and other structures (type, size, span arrangement and location).
- General drainage conditions.

2.5 Pavement Condition Survey

The Pavement Condition Survey has been carried out in accordance with IRC Guidelines. All surveys and investigations have been carried out with the following objectives:

- To have an up to date record of road assets.
- To have a clear understanding of road side features including land use, drainage characteristics, etc. and
- To assess the condition and strength data for developing improvement proposals and related designs.

2.5.1 Visual Condition Survey

Visual Condition Survey of the road sections has been carried out by travelling along the patching, rutting, pot holes, edge breaking, etc. by visual observations in a well structured data format. The data so collected has been compiled and presented (kilometer wise) in the form of tables for easy understanding. This data has been used to assess the pavement condition.

2.5.2 Soil, geotechnical, material, hydrology and drainage surveys

(i) The activities and Deliverables forming part of the soil, geotechnical, material, hydrology and drainage surveys are described below:

(a) The characteristics of the existing soil of the Project road.

(b) The determination of sub grade CBR (soaked) Project road.

(c) Benkelman Beam Deflection measurements on the Project road for overlay stretches.

(d) Preliminary hydraulic data for bridges, design discharge, HFL, LWL, etc. with a view to checking adequacy of existing waterway.

(e) A broad assessment of the drainage condition and requirement of the Project Highway.

(ii) Road signs, safety devices

(a) The provision of Road Signs, Pavement Markings, Safety Barriers, Railings, Delineators, Chevron Markings, Traffic Attenuators. It shall also include Crash Barriers for existing bridges.

(b) Overhead signs on the Project road and provide an outline of the same giving size and location.

Chapter -3
DESIGN STANDARD & SPECIFICATION

3.1 General

Planning and design of roads & CD structures, pedestrian facilities and street furniture are essentially based on the IRC standards and MoRT&H specifications. Whenever, the codes / standards are silent on some of the aspects, the same has been planned / designed based on sound engineering practices. Design standards relevant to the project road along with the broad list of design parameters and the relevant IRC codes / specifications have been detailed in **Table 3.1.**

Table 3.1: Design Standards

SL No.	Design Parameters	Reference Code
1.	Geometric Design Standards • Carriageway width • Shoulder • Footpath • Median • Camber • Super Elevation • Horizontal Alignment • Vertical Alignment	As per IRC: 38 - 1988, IRC: 86 - 1983 & IRC: SP : 23 – 1993
2.	Road Furniture • Road Delineators • Road Markings • Road Signs	 As per IRC: 79 – 1981 As per IRC: 35 – 1997 As per IRC: 67 – 2001
3.	Road Capacity	As per IRC: 106 – 1990
4.	Pavement Design	As per IRC: 37 – 2012 & IRC: SP 62 - 2014
5.	Overlay Design	As per IRC: 81 – 1997
6.	Road Drainage	As per IRC: SP: 42 - 1994 & IRC: SP: 50 - 1999
7.	Culverts	As per relevant IRC codes and MoRT&H

The project road section passes through plain terrain. Design standards (as appropriate) have been further elaborated under the following heads:

- ❖ Geometric Design
- ❖ Pavement Design
- ❖ Drainage
- ❖ Road Furniture and Appurtenances
- ❖ Bridges and CD Structures

3.2 Design Standards Related to Geometric Design

Design standards related to road geometric along with the suggested design values / standards and recommended values based on site conditions and data analysis are detailed in Table 3.2.

Table 3.2: Geometric Design Standards

SL No.	Design Parameters	Design Values
1.	Design Speed	Design speed Considered is 40 kmph.
2.	Geometric Design Standards	
	• Carriageway Width	Two lane carriageway
	• Camber (Bi-directional)	2.5% for paved carriageway.
	• Super Elevation	Limited to 4%.
	• Footpath	Minimum width - 1.5m
	• Kerb	Barrier / Semi — barrier / Mountable (Barrier type recommended)
	• Extra Widening at Curves	Nil for Radius above 300 m
	• Gradient	Maximum Gradient - 4.0 % (1 in 25) Minimum Gradient for Drainage - 0.5 % (desirable minimum) & 0.3 % (absolute minimum).

3.3 Design Standards Related to Pavement Design

Design standards related to Pavement design are essentially based on the guidelines given in IRC: 37 - 2012 "Tentative Guidelines for the Design of Flexible Pavements " and IRC SP 62-2004 "Guidelines for the Design and Construction of Cement Concrete Pavements for Rural Roads". The suggested design values / standards and recommended values based on site conditions and data analysis are detailed in Table 3.3 and are adapted in the design.

Table 3.3: Design Standards

SL No.	Design Parameters	Reference Code / Design Values
1.	Pavement design	IRC: 37 - 2012 " Tentative Guidelines for the Design of Flexible Pavements "
	Initial Traffic	In terms of CVPD, vehicles weighing more than 3 ton
	Traffic growth rate	5%
	Design Life	10 to 15 years
	Vehicle damage factor	1.5 to 4.5
2.	Soil Characteristics	CBR Value

3.4 Design Standards Related to Overlay Design

Design standards related to Overlay design are essentially based on the guidelines given in IRC: 81 - 1997 "Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique". The suggested design values / standards and recommended values based on site conditions and data analysis are detailed in Table 3.4 and are adapted in the design.

Table 3.4: Overlay Design Standards

Sl. No.	Design Parameters	Reference Code / Design Values
1.	Overlay Design	IRC: 81 - 1997 "Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique"
	• Design Life	10 years
	• Correction Factors	Temperature Correction Factor. Correction for Seasonal Variation (inclusive of correction for moisture content, soil type and rainfall)
	• Minimum Thickness	From structural considerations recommended minimum bituminous overlay thickness is 40 mm AC (minimum) or 50mm BM (as required) + 40mm BC
2.	Wearing Course Material (Options)	Bituminous Concrete with Crumb Rubber Modified Bitumen / Plastic Waste.

3.5 Design Standards Related to Road Drainage

Drainage of water from pavement surface is of paramount importance as far as preserving the road assets created by investing huge funds in addition to maintaining the structural soundness and functional efficiency of the road. Design standards related to road drainage are essentially based on the guidelines given in IRC: SP: 42 — 1994 "Guidelines on Road Drainage" and in IRC: SP: 50 - 1999 "Guidelines on Urban Drainage". The suggested design values / standards are detailed in **Table 3.5.**

Table 3.5: Design Standards Related to RoadDrainage

SI No.	Design Parameters	Design Values
1.	• Camber	1.7 - 2.5 % (bi - directional) for carriageway (camber of 3% is adopted).
	• Longitudinal Gradient	Minimum 0.3 - 0.5% for satisfactory drainage
	• Drain Type	Cast in situ RCC box drain with Precast RCC cover slab. RCC box culverts across cross roads.
	• For Existing Drains	Desilting and Rectification of Damaged Portion

3.6 Design Standards Related to Road Furniture and Appurtenances

Utility and importance of the road are greatly enhanced by installing road furniture and appurtenances at appropriate locations along the project road, which ensures improved road safety. Planning and design of road furniture and appurtenances are as per the guidelines stipulated in IRC. Detailing of each of these components has been done so as to integrate the same with the road improvement scheme. The suggested design values / standards are detailed in **Table 3.6.**

Table 3.6: Design Standards Related to Road Furniture and Appurtenances

SL No.	Design Parameters	Reference Code / Design Values
1.	Road Markings	IRC: 35 - 1997 "Code of Practice for Road Markings".
2.	Road Signs	IRC: 67 - 2001 "Code of Practice for Road Signs".
3.	Road Delineators	IRC: 79 - 1981 "Recommended Practice for Road Delineators".
4.	Pedestrian Facilities	IRC: 103 - 1988 "Guidelines for Pedestrian Facilities".

In addition to the above measures various other integral road components have been planned so as to achieve the maximum and optimal use of the carriageway with no / least interference to traffic flow at the same time ensuring adequate facilities to other road users especially pedestrians. All the encroachments, if any shall be cleared within the RoW.

3.7 Design Standards Related to Bridges and CD Structures

The design standards and loading considered for culverts and bridges are as stipulated in latest IRC codes / Special publications supplemented by appropriate MOST circulars and/or IS codes. The unsafe and/or deficient bridge and culvert structures (existing) will be rehabilitated or replaced by sound structures.

Chapter -4
DESIGN & PROPOSALS

4.1 General

Improvement proposals for an existing road section essentially consist of two components, geometric and structural improvements. Geometric improvement deals with visible dimensions of roadway, probable road widening and is dictated by the traffic and economic considerations. Due to the inherent restrictions like limitation in land acquisition, limited right of way and existing utilities / services, etc. the horizontal and vertical alignments in general follow the existing geometry except in situations where improvements are possible. The geometric improvements mainly involve improvements to cross sectional elements such as carriageway, shoulders, etc. The structural component deals with the pavement and embankment design aspects, i.e., the ability of the roads to adequately carry and support the Vehicle / wheel loads over the design period. Safety, speed, efficiency, economy and comfort in traffic movement to a large extent are governed by adequacy of design standards used for a specific road facility.

The improvement proposals need to consider the method of widening like concentric or eccentric to the existing road which is dictated by site situations like available land for acquisition, curvature, existing utilities, terrain, places of worship, monuments, grave yards, places of importance etc.

This chapter deals with the analysis of data collected during various engineering surveys/investigations and the formulation of improvement proposals including planning and design.

4.2 Road Inventory and Physical Characteristics of Road Section

Investigations / studies have been carried out along the Project Stretch. Physical characteristics of these road and road Junctions are as follows.

Terrain along this section is generally plain. Width of Carriageway (Undivided Carriage Way) along the Road varies. The Road carries considerable vehicular traffic throughout the day especially during peak hours. Considerable pedestrian traffic is also present along the corridor.

along the Road varies. The Road carries considerable vehicular traffic throughout the day especially during peak hours. Considerable pedestrian traffic is also present along the corridor.

4.3 Pavement Design

Pavement design forms an integral part of detailed engineering study. Performance of pavement is critical as the economical returns are directly dependent on its performance. This chapter deals with the design methodology adopted for the construction, strengthening and rehabilitation of the existing carriageway and the also suggests the design approach for both flexible and rigid pavement for the new carriageway. This chapter also brings out the present condition of the project corridor, the pavement option study and suggests the best alternate design.

This Section describes the studies and investigation carried out on Traffic, existing pavement conditions, existing soil sub grade condition and existing embankment / Soil at OGL condition. New pavements are generally flexible, consisting of Granular Sub-base, Water Mix Macadam and wearing course in Bituminous Concrete. Rigid pavement life span is longer (often more than 30 years) and maintenance is supposed to be less than for flexible pavement.

4.4 Pavement Design Methodology

Pavement design methodology includes two basic functions namely; design of strengthening and Widening for existing pavement and design of new crust for new Pavement to be to be adopted shall be decided based on life cycle cost analysis as a part of pavement design methodology, Accordingly, the following Methodology has been adopted in Pavement design.

Step 1: Various Pavement investigations have been carried out on the project corridor to assess the adequacy of the existing pavement crust. These investigations include:

- Visual Pavement Condition
- Visual shoulder condition
- BBD measurements
- Sub grade investigations
- Investigations on existing soil / granular layers

Step 2: Detailed material investigations have been conducted in the projected influence area and strength characteristics and availability of construction material has been determined.

Step 3: For the purpose of designing the overlay, the project corridor has been divided into homogeneous sections based on deflection measurements using Cumulative standards approach. Design thickness of overlay has been estimated from IRC-81-1997 using estimated traffic level and characteristic deflection of particular homogeneous section. Estimated BM thickness is then adjusted to equivalent thickness of BC & DBM using conversion factors

given in IRC 81-1997.

Step 4: Homogeneous sections for pavement design have been established and design traffic Loadings for each of them identified. Design of flexible pavement for new road has been carried out in accordance with guidelines of IRC-37-2012.

Step 5: Design of rigid pavement has been carried out as per IRC-58-2011 method.

Step 6: Design of flexible pavement for paved shoulders, service roads, and interchange ramps has been carried out in accordance with IRC 37-2012 guidelines.

4.5 Flexible Pavement Design

4.5.1 Design CBR

Existing soil sub grade samples were collected through Trial Pit excavations at Road and shoulder interface. The existing soil sub grade were tested as per IS 2720.

The equivalent CBR is obtained as per IRC 37-2012 Chart for 905 dependability is 10%. Hence the flexible pavement design has been carried out using the IRC code (IRC-37-2012). In this code, pavement designs have been extended to cover up to 150msa and design CBR strengths up to 15%. In order to compute the damage ratio, the allowable repetitions are calculated in terms of the fatigue and rutting. The pavement design was done as per IRC-37-2012 and IIT Pave software. It accepts layer thickness, loading and material characteristics as inputs and has provisions for entering various indigenous data such as rutting and fatigue coefficients, wheel spacing, tyre pressure etc. The analysis is based on the linear elastic, multilayer theory and the stresses and strains developed in various layers of the pavement are obtained.

4.5.2 Design Life for Base and Sub-base Layers

The stage construction for first five years of pavement life is considered as an option. It would be appropriate to design the bottom non bituminous layers (base and sub-base) for axle loads expected in the 15 year design period the upper bituminous layers for axle loads expected at the end of 10 year design period. A 15-years design life has been considered for Base and Sub-base layers of flexible pavement.

4.5.3 Traffic Considerations

The base year traffic, traffic growth and the projected traffic for the design period for each category of vehicles have been arrived from the Traffic Studies. The commercial vehicle considered for the design are based on the vehicular projections considering the actual traffic, the traffic likely to be generated by future developments in the vicinity of the project road. Further, based on the traffic studies the number of commercial vehicles has been adopted.

4.5.4 Traffic Loading

In accordance with the requirement of IRC: 37-2012, the traffic loading for the design period and design lane are to be assessed. Vehicles constituting the commercial vehicles are LCV, 2 Axles, 3 Axles and Multi Axles and Multi Axle Semi Articulated vehicles.

4.5.5 Design Approach and Criteria of Flexible pavement

Pavement distress resulting from repeated application of traffic;

- Horizontal tensile strain at the bottom of the bituminous layer
- Vertical compressive strain at the top of the Sub grade

4.5.6 Design Standards Related to Pavement Design

Design standards related to pavement design are essentially based on the guidelines given in IRC: 37-2012 – "Tentative Guidelines for Design of Flexible Pavements".

Table 4. 1 Pavement Design Standards

	Design Parameters	Reference Code / Design Values
1.	Pavement Design	IRC: 37-2012- "Tentative Guidelines for Design of Flexible Pavements"
	Traffic Growth Rate	Adopted as per IRC: 37-2012
	Design Life	Stage Construction: • 15 years for base and sub base • 8 years for bituminous layers
	Vehicle Damage Factor	Derived values based on Axle load survey. If these values are less than national average, then national average will be used.
	Lane Distribution Factor	As per IRC:37-2012
2.	Wearing Course Material (Options)	Bituminous Concrete with VG 30 (50 x 70 Grade)
3.	Mastic Asphalt	Near junctions, roundabouts and bus stops. Over major/minor bridges

4.5.7 Information required for estimating design traffic

- Initial traffic in terms of number of Commercial Vehicles per day (CVPD).
- Traffic growth rate during the design life in percentage.
- Design life in number of years.
- Spectrum of axle loads.
- Vehicle Damage Factor (VDF).
- Distribution of commercial traffic over the carriageway.

4.5.8 Computation of Design Traffic

The design traffic in terms of the cumulative number of standard axles to be carried during the design life of the road should be computed using the following equation:

$$N = \frac{365 * \left[(1+r)^n - 1\right]}{r} * A * D * F$$

Where,

N = Cumulative number of repetitions in terms of million standard axles

A = Initial traffic in the year of completion of construction in terms of the number of Commercial Vehicles per Day (CVPD).

D = Lane distribution factor (as explained in Para 4.5.1 (IRC: 37-2012)

F = Vehicle Damage Factor (VDF).

n = Design life in years.

r = Annual growth rate of commercial vehicles in decimal (e.g., for 5 per cent annual growth rate, r = 0.05).

Traffic Growth Rate

The present day traffic has to be projected for the end of design life at growth rates ('r') estimated by studying and analyzing the following data:

(i) The past trends of traffic growth; and

(ii) Demand elasticity of traffic with respect to macro-economic parameters (like GDP or SDP) and expected demand due to specific developments and land use changes likely to take place during design life.

If the data for the annual growth rate of commercial vehicles is not available or if it is less than 5 per cent, a growth rate of 5 per cent should be used.

The traffic in the year of completion is estimated using the following formula:

$$A = P (1+r)^n$$

Where,

P = Number of commercial vehicles as per last count.

n = Number of years between the last count and the year of completion of construction

4.5.9 Selection of Subgrade CBR for Pavement Design

The CBR values of the sub grade soil vary along a proposed alignment even on a homogeneous section. The pavement design is done based on Considering the CBR of Borrow area for Reconstruction and Widening Section and For Existing portion the CBR of Existing Sub grade / Sub base is considered.

4.5.10 Flexible Pavement Design – Re-construction

The CBR values of the subgrade soil vary along a proposed alignment even on a homogeneous section. The pavement design is done based on Considering the CBR of Borrow area for Reconstruction and Widening Section and For Existing portion the CBR of Existing Subgrade/Sub base is taken,

4.5.11 Widening Proposals & Typical Cross Sections

a) Widening options for the project road were arrived based on,

- Lane requirements based on traffic capacity analysis.
- Requirement of service roads along built-up areas.
- Presence of religious structures.
- Availability of land

Formulation of carriageway widening schemes involves 1) estimation of extent of widening required in terms of additional lanes and 2) lateral arrangement of these additional lanes to the existing carriageway. Guidelines for the requirement of additional lanes is derived from, Traffic Study – Projected Traffic Volume vis-à-vis Capacity of each lane / road

Based on the TOR requirement of minimum Land Acquisition, i.e., within the existing ROW as far as possible, and retaining the existing pavement, cross drainage structures and bridges as far as possible, without compromising the recommendations of IRC / MORT&H.

Requirement of service roads along built-up areas. Additional lanes shall be added to the existing road either concentrically or eccentrically, depending on

1. The availability of right of way on either side of the existing centre line,
2. Topography and built-up areas
3. Due to specific field constraints (such as any sensitive features like water bodies, important structures etc.), localized shifting has been emerged at many places. However the actual widening will be finalized on the basis of field survey data, study of soil erosion and possibility of landslide and after completing the Environmental Assessment (EA) and Social Impact Assessments (SIA) of widening and Public Consultation.

b. Truck lay-bye and Bus bay pavement

In the case of rural areas, it is recommended to provide interlocked concrete block (M40) pavements for truck lay bye and Bus bays. An interlocked concrete block pavement resembles the structure of flexible pavement with an exception that in place of asphalt layers, cement concrete blocks are used with a levelling course of sand on top of the Base layer.

4.6 Proposed Improvements to Road Section

The proposals for the improvement of the geometric elements of the existing project road sections generally include: